SPACECRAFT SYSTEMS

B.N. Agrawal, Professor
Department of Aeronautics and Astronautics
Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: The goal of this project was to develop four spacecraft laboratories at NPS: FLTSATCOM Laboratory, Spacecraft Test Laboratory, Spacecraft Dynamics and Control Laboratory, and Spacecraft Design Laboratory. It is a continuing project.

SUMMARY: During the reporting period, significant progress has been made in several areas. In the Spacecraft Attitude Dynamics and Control Laboratory, implementation of the dSPACE Real Time Control System on the NPS Flexible Spacecraft Simulator (FSS) has been successfully completed and the FSS has been made operational. The Computational Spacecraft Design Laboratory was upgraded both in hardware and software, including Pro/ENGINEER, Pro/Mechanica, MSC/Nastran and COSMOS/M Engineer. Three spacecraft design projects were completed. The mission for the first project was to investigate three asteroids in the main belts. The project was done under AIAA/Lockheed Martin Graduate Competition and won second position. The second project was on a medium earth orbit UHF satellite constellation. This project was sponsored by the Naval Space Command and was in direct support of DoD's effort to analyze alternative solutions for the replacement of the UHF Follow-on (UFO) constellation. The third project was EHF satellite with a classified payload.

PUBLICATIONS:

Agrawal, B., Song, G., and Buck, N., "Slew Maneuvers of Flexible Spacecraft Using Input Shaping and Pulse-Width Pulse-Frequency Modulated Thrusters," IAF-97-A.2.09, *Proceedings of the 48th International Astronautical Congress,* Turin, Italy, 6-10 October 1997.

Agrawal, B., McClelland, R., and Song, G., "Attitude Control of Flexible Spacecraft Using Pulse-Width Frequency Modulated Thrusters," accepted for publication in *Space Technology Journal*.

Song, G., Buck, N., and Agrawal, B., "Spacecraft Vibration Using Pulse-Width Pulse Frequency Modulated Input Shaper," *Proceedings of AIAA Guidance, Navigation, and Control Conference*, New Orleans, LA, 11-13 August 1997.

Yale, G. and Agrawal, B., "A Lyapunov Controller for Cooperative Space Manipulators," accepted for publication in AIAA *Journal of Guidance, Control, and Dynamics.*

DoD KEY TECHNOLOGY AREA: Space Vehicles

KEYWORDS: Spacecraft Design, Spacecraft Attitude Control, Space Manipulator

A NOVEL TECHNIQUE FOR SEARCH AND GEOLOCATION OF SIGNALS FROM LOW-EARTH ORBIT

David D. Cleary, Associate Professor
Department of Physics
Sponsor: United States Navy

OBJECTIVE: The objective is to investigate new techniques for search and geolocation using receiver systems that have both wide field-of-view and high gain.

SUMMARY: An imaging system was designed that can operate at radar frequencies and has in principle both wide field-of-view and high gain. This system makes use of a technique known as multiplexed imaging. The concept of operations (CONOPS) under which this device would be used was developed. Currently, the expected performance of this device is being analyzed including the estimated sources of system noise.

OTHER:

A Multiplexed Imaging System for Microwave Frequencies, Navy Case No. 78779 (patent filed).

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Hyperspectral Imaging

THEATER BALLISTIC MISSILE DEFENSE-MULTI-SENSOR FUSION, TRACKING, AND TARGETING TECHNIQUES

Robert G. Hutchins, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Navy Tactical Exploitation of National Capabilities (TENCAP) Office

OBJECTIVE: The ultimate goal is to assess the feasibility of algorithms employing both strategic and theater sensors to detect, track, and engage theater ballistic missiles during boost and/or early ballistic missile flight, destroying the missile over the territory of the aggressor.

SUMMARY: The research this past year has focused on initialization and tracking of ballistic missiles during boost phase and through the transition between boost and ballistic flight. Various tracking algorithms have been studied. The effects of initialization on tracker performance to assess the feasibility of performing a hand-off between satellite and earth-based sensors are currently being examined.

PUBLICATION:

Hutchins, R.G. and San Jose, A.P., IMM Tracking of a Theater Ballistic Missile during Boost Phase," Oliver Drumond, (ed.), *Proceedings of SPIE Signal and Data Processing of Small Targets*, Vol. 3373, pp. 528-537, 1998.

CONFERENCE PRESENTATION:

Hutchins, R.G. and San Jose, A.P., "IMM Tracking of a Theater Ballistic Missile during Boost Phase," SPIE Signal and Data Processing of Small Targets, Orlando, FL, April 1998.

DoD KEY TECHNOLOGY AREAS: Sensors, Modeling and Simulation

KEYWORDS: Theater Ballistic Missiles, Sensors, Extended Kalman Filters, Data Association, Target Tracking

PROJECT GUSTY ORIOLE, COMPUTER ALGORITHMS AND ARCHITECTURES FOR SPACE APPLICATIONS

Herschel H. Loomis, Professor
Department of Electrical and Computer Engineering
Sponsor: Secretary of the Air Force

OBJECTIVE: This project is concerned with the application of computer algorithms to specific military space projects, the development of specialized computer architectures for military space applications and the support of the space operations curriculum.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Military Space, Computer Architectures

RADIATION HARDENING OF SPACE-BASED ELECTRONIC DEVICES AND SOLAR CELLS

Sherif Michael, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Research Laboratory

OBJECTIVE: To study the space radiation effects on state-of-the-art solar cells including GaAs and InP cells. To investigate annealing methods developed in previous NPS research on the recovery of radiation degraded performance of advanced space cells and develop radiation hardened Analog VLSI circuits for space applications.

SUMMARY: Continuation of the ongoing research on Photovoltaic Power Technology. Research tasks include optimizing current annealing methods previously developed for GaAs cells. The tasks also include investigating of the new laser annealing technique on GaAs and InP solar cells. Irradiating solar cells using NPS Linear Accelerator, and measuring their characteristics using the newly developed Solar Simulator Facilities. Other tasks are to investigate radiation effects on different electronic devices. Radiation testing of Analog VLSI chips previously designed and fabricated, suing the NPS Linear Accelerator. Major Research: 1) annealing of radiation-damaged solar cells, 2) investigating of Laser Annealing techniques for radiation-damaged solar cells, and 3) radiation tolerant ASIC and analog IC design, implementation and testing.

PUBLICATIONS:

Michael, S., Shehata, K, and Fouts, D., "Analog/Digital Gallium Arsenide Circuits and Systems Design," *Proceedings of the 40th Midwest Symposium on Circuits and Systems,* Sacramento, CA, August 1997.

Michael, S., Shehata, K., and Fouts, D., "Dynamic Logic Families for Complementary Gallium Arsenide (CgaAs) Fabrication Processes," *Proceedings of the 40th Midwest Symposium on Circuits and Systems, Sacramento,* CA August 1997.

Michael, S. and Oldland, H., "A GaAs Mixed Mode Switched Capacitor VLSI," *Proceedings of the 40th Midwest Symposium on Circuits and Systems,* Sacramento, CA, August 1997.

CONFERENCE PRESENTATION:

Michael, S., "A GaAs Mixed Mode Switched Capacitor VLSI," 40th Midwest Symposium on Circuits and Systems, Sacramento, CA, August 1997.

THESES DIRECTED:

Oldland, H., "The VLSI Implementation of a GaAs GIC Switched Capacitor Filter," Master's Thesis, Naval Postgraduate School, June 1997.

Reason, J., "A Comparative Study of Nuclear Technology and Direct Energy Conversion Methods for Space Power Systems," Master's Thesis, Naval Postgraduate School, June 1997.

DoD KEY TECHNOLOGY AREA: Other (Environmental Effects)

KEYWORDS: Space Radiation Effects, Satellites, Annealing Radiation Hardened

SPACE SYSTEMS STUDENTS THESIS RESEARCH PROJECTS

Rudolf Panholzer, Professor
Space Systems Academic Group
Sponsor: Naval Research Lab

OBJECTIVE: The objective of this proposal is to fund Space Systems Academic Group (SSAG) students thesis research projects, directed studies, and space engineering experience tours.

THESES DIRECTED:

Elder, J.T., "Optimal Impulse Conditions for Deflecting Earth Crossing Asteroids," Master's Thesis, Naval Postgraduate School, June 1997.

Horning, J.A.,, "System Controller Hardware and Embedded Software for the Petite Amateur Navy Satellite (PANSAT)," Master's Thesis, Naval Postgraduate School, September 1997.

Lahti, C.A., "The Design of the Radio Frequency (RF) Subsystem Printed Circuit Boards for the Petite Amateur Navy Satellite (PANSAT)," Master's Thesis, Naval Postgraduate School, June 1997.

Lambley, A.S., "Evaluation of Layout Techniques for Radiation Tolerant Bulk CMOS Integrated Circuits," Master's Thesis, Naval Postgraduate School, September 1997.

Reason, J.P., "A Comparative Study of Nuclear Technology and Direct Energy Conversion Methods for Space Power Systems," Master's Thesis, Naval Postgraduate School, June 1997.

Smilowitz, G.J., "Final Design, Integration, and Validation of the PANSAT Antenna System," Master's Thesis, Naval Postgraduate School, March 1997.

Stelianos. H., "The Use of Commercial Low Earth Orbit Satellite Systems to Support DoD Communications," Master's Thesis, Naval Postgraduate School, December 1996.

Triska, N.E., "The Astrodynamic Problems of Digital TDMA Signal Detection," Master's Thesis, Naval Postgraduate School, December 1996.

DoD KEY TECHNOLOGY AREAS: Aerospace Propulsion and Power, Space Vehicle, Sensors, Command, Control, and Communications, Electronics, Other (Space)

KEYWORDS: Satellite Digital Communications, Direct Sequence Spread Modulation, Over-The-Horizon Communications, Amateur Satellite, Thin-Film Ferroelectric Material

SPACE OPERATIONS EXPERIENCE TOURS

Rudolf Panholzer, Professor
Space Systems Academic Group
Sponsor: Naval Space Command

OBJECTIVE: The objective is to provide direct interaction between the signatories to further promote and guide a focused, well-defined, and well-planned support system essential to ensure a successful experience tour program. This program will provide valuable opportunities for practical professional development of students at NPS and will be an important investment in the Department of the Navy's strategy for Space Systems.

THESIS DIRECTED:

Bradley, D.R., "A Requirements Analysis of the 2008 MILSATCOM Architecture," Master's Thesis, Naval Postgraduate School, September 1997.

Carlan, M.J., "A Future Space Intelligence Architecture," Master's Thesis, Naval Postgraduate School, September 1997.

Padget, S.A., "Issues in Space Law and Policy," Master's Thesis, Naval Postgraduate School, December 1996.

DoD KEY TECHNOLOGY AREAS: Aerospace Propulsion and Power, Space Vehicles, Sensors, Command, Control, and Communications, Electronics, Other (Space)

KEYWORDS: Satellite Digital Communications, Direct Sequence Spread Modulation, Over-the-Horizon Communications, Amateur Satellite, Thin-Film Ferroelectric Material

NAVAL SPACE SYSTEMS ACADEMIC CHAIR
Rudolf Panholzer, Professor
Craig Baldwin, Naval Space Systems Academic Chair
Space Systems Academic Group
Sponsor: Naval Space Command

OBJECTIVE: The incumbent of the Naval Space Systems Academic Chair engaged in instruction and research and act as consultants in the area of specialization to students and faculty of the Naval Postgraduate School.

DoD KEY TECHNOLOGY AREA: Other (Space)

KEYWORDS: Satellite Digital Communications, Direct Sequence Spread Modulation, Over-the-Horizon Communications, Amateur Satellite, Thin-Film Ferroelectric Material

FERROELECTRICITY RESEARCH NEWSLETTER
Rudolf Panholzer, Professor
Space Systems Academic Group
Sponsor: Office of Naval Research

OBJECTIVE: A quarterly research newsletter designed to supply information on national and international symposia, conferences, workshops, and meetings which deal with topics of interest to scientists, engineers, and students in the field of integrated ferroelectrics research was produced quarterly.

DoD KEY TECHNOLOGY AREA: Materials, Processes, and Structure

KEYWORDS: Integrated Ferroelectrics

SPACECRAFT DESIGN INSTRUCTION AND RESEARCH SUPPORT
Rudolf Panholzer, Professor
Space Systems Academic Group
Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: The objective of this proposal is to fund Space Systems Academic Group (SSAG) facilities development for spacecraft design, development, and test.

DoD KEY TECHNOLOGY AREA: Space Vehicles

KEYWORDS: Satellite Digital Communications, Direct Sequence Spread Spectrum Modulation, Over-the-Horizon Communications.

NEAR-EARTH-OBJECT INTERCEPTION
I. Michael Ross, Associate Professor
Space Systems Academic Group
Sponsor: Johns Hopkins University

OBJECTIVE: This proposal is for the purpose of analyzing certain problems associated with near–Earth-object interception. These problems need to be addressed today so that the United States and the world, at large, will be prepared to handle them when they occur tomorrow.

DoD KEY TECHNOLOGY AREA: Other (Space)

KEYWORDS: Space Warfare

CENTER FOR RESEARCH INTO THE MILITARY APPLICATIONS OF SPACE
Alan Ross, Tactical Exploitation of National Capabilities (TENCAP) Chair Professor
Space Systems Academic Group
Sponsor: Naval Engineering Logistics Office

OBJECTIVE: Funds are provided for the newly created center for research into the military application of space at NPS.

DoD KEY TECHNOLOGY AREA: Other (Space)

KEYWORDS: Military Applications of Space